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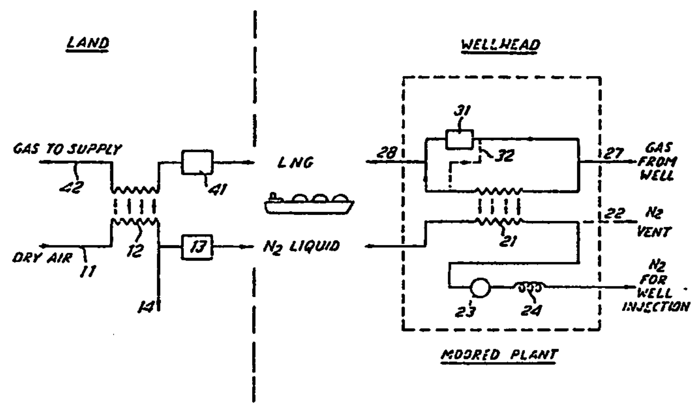
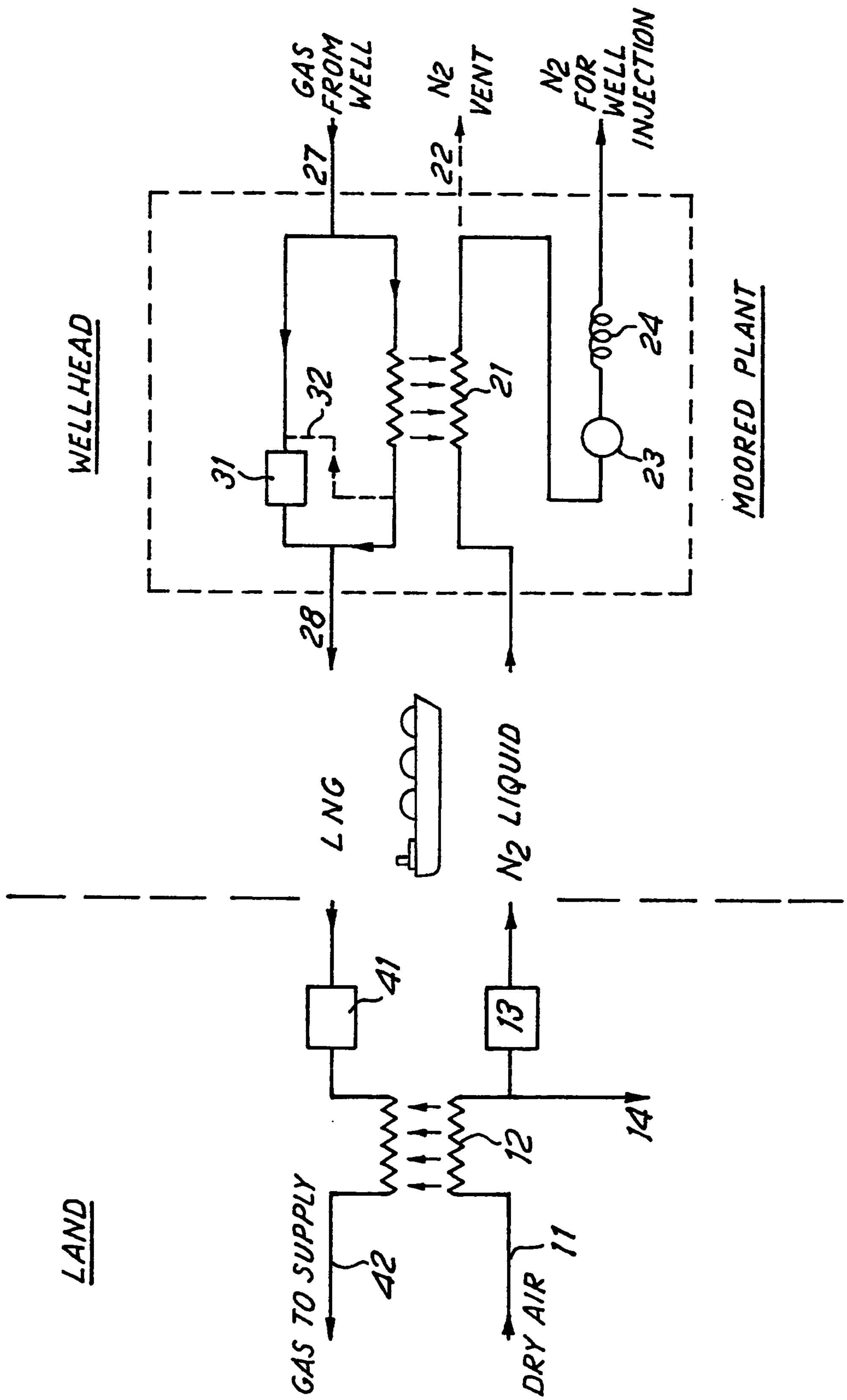
(54) Gas and oil handling

(57) A coolant gas, eg nitrogen, is liquefied in a land-based plant 12, transported to an off-shore wellhead, supplied to a heat-exchanger 21 to liquefy natural gas 27, and then passed via compressor 23 and heater 24 for use in an enhanced oil recovery (EOR) process. A supplementary refrigeration plant 31 may be provided at the wellhead. The heat-exchanger 21 is mounted on an off-shore platform or a vessel stationed at the wellhead. The same vessel may be used to transport liquified nitrogen and liquified natural gas in opposite directions and the liquified natural gas may be used to liquify the nitrogen in the land-based plant 12.



The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.


WELLHEAD
GAS FROM WELL
N2 VENT
N2 FOR WELL INJECTION
27
22
21
23
24
31
32
28
MOORED PLANT
LNG
N2 LIQUID
LAND
41
13
12
14
11
42
GAS TO SUPPLY
DRY AIR

SPECIFICATION

Gas and Oil Handling

The present invention relates to the handling of gas and oil and in particular natural gas and oil which has been obtained from beneath the sea.

Existing methods for conveying such gas to land involve the use of a network of collection pipes which is very expensive for wells in deep waters or remote locations. The existing main pipe networks under the North Sea were built to serve a series of sub-routes, which are intended to be connected as and when the further sources are developed, so that the capital expenditure on the main arteries is well utilised. When it comes to developing the outlying sources, the necessary extension pipelines may have only a short working life and are not easily recoverable for use elsewhere, so that the capital has to be written off in a relatively short time and possibly on a relatively small production run. The greater the distance from the main network, the less the likelihood of the source being developed. If at any prospective source, the oil is to be loaded direct to tanker, then the gas would normally be flared off at the wellhead and its value is not available to offset capital or running costs. If the well is developed only for the oil, then not only is the gas unavailable as a cost bonus, but the energy content is lost forever. If the well is not viable for oil alone but viable if both oil and gas are recovered (after allowing for the cost of the gas recovery) then it will not be developed unless a economic means of wellhead gas recovery exists.

Liquefaction of natural gas obtained from land-based sources is known and usually employs recirculation of a multi-component refrigerant; the advantage of such liquefaction is that the costs of subsequent transport by road or by sea is considerably reduced. However it is considered prohibitively expensive to provide a full-scale refrigerating liquefaction plant at a sea-based well.

One solution to the above problem is proposed in G.B. patent 1596330. According to this proposal, a sea-going vessel is adapted to store and transport liquefied gas, gaseous natural gas and a liquefied gas being passed through a heat exchanger on board the vessel so that the gaseous natural gas is liquefied.

The present invention seeks to provide an improved solution which is capable of particularly economic operation.

According to a first aspect of the present invention there is provided a method of handling natural gas and oil from a relatively inaccessible site comprising liquefying a cooling medium at a relatively accessible site, transporting the liquefied cooling medium to the relatively inaccessible site, and passing it through a first branch of a heat exchanger and simultaneously passing natural gas through the second branch of the heat exchanger, thus liquefying the natural gas, the cooling medium then being employed in an enhanced oil recovery process at the relatively inaccessible site.

The natural gas is then transported away from the relatively inaccessible site, preferably after having been stored there. The cooling medium is used once only for cooling at the wellhead and is not recycled, i.e.is not employed in a continuous closed circuit.

The cooling medium is preferably nitrogen.

The liquefied natural gas may be transported back to a said relatively acessible site, where it may be stored as liquid reservoir gas, and during subsequent vapourisation may be used to assist in liquefying a subsequent cargo of cooling gas.

According to a second aspect of the present invention there is provided a natural gas liquefaction and enhanced oil recovery plant suitable for provision at a relatively inaccessible wellhead comprising a heat exchanger with a first branch arranged to receive liquid cooling medium and supply vapourised cooling medium and a second branch arranged to receive natural gas vapour and supply liquefied natural gas, the outlet of the first branch being connected to enhanced oil recovery apparatus.

The plant may be supplemented by a smaller recycling (i.e. closed-circuit) refrigerating liquefaction plant.

The vapourised cooling medium at the outlet of the second branch may be supplied to a compressor and/or a heater before passing to the enhanced oil recovery apparatus.

A preferred embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawing which illustrates a method of conveying natural gas from an offshore well to land.

Basically the method comprises the liquefaction of a common gas on a convenient mainland site, and shipping this liquefied gas to the offshore wellhead. There it is used in liquefaction of natural gas from the well, through the medium of a heat exchanger. At the land site dry air 11 is liquefied in plant 12, which incorporates a heat exchanger, and separated into a liquid nitrogen fraction 13 and a fraction 14 containing oxygen and other components.

The liquid nitrogen is then shipped by tanker to the offshore wellhead where it is stored until required for use. In use it is fed to one branch of a heat exchanger 21 of a liquefaction plant where it vapourises. The nitrogen is fed to a compressor 23 and a heater 24 and is then used for Enhanced Oil Recovery (EOR). In this process vapourised nitrogen is injected into a well in order to increase the mobility of and to force out more oil, and possibly natural gas. If desired some or all of the nitrogen vapour may be vented to the atmosphere at 22.

The compressor 23 and the heater 24 are to be designed to give a range of available pressures and temperatures at the injection point in the reservoir. The pressure will need to be several thousand pounds per square inch depending on the depth and current characteristics of the particular reservoir, and the temperature can be varied to give optimum results. The compressed nitrogen is then available for feeding into the reservoir by means of an apparatus similar to that for re-injecting natural associated gas back into oil wells.

The energy necessary for driving the compressor and for the heater can be obtained by using the fuel

available from the well.

Natural gas 27 from the well is simultaneously supplied to the other branch of the heat exchanger 21, where it is liquefied by virtue of heat exchange with the nitrogen in the first branch. The liqufied natural gas (LNG) 28 is then loaded on to a tanker (after being stored if desired) and shipped to an established collection point on land.

In practice, an optimum sized mobile liquefaction plant is stationed near each wellhead in turn. The plant can be on a ship or on a platform (sea-bed or semi submersible). It is more convenient and safer for the heat exchanger not to be on the same vessel as the tanks for transporting the liquefied gases to and from land. Energy for the plant is provided by use of some of the gas and a minimal burn-off will be necessary to deal with other undesirable constituents.

A small recycling refrigerating liquefaction plant 31 is provided at the wellhead which may be used as a "top-up" to the cooling effect of the nitrogen (indicated by path 32). Plant 31 may be arranged to operate on its own if a nitrogen cargo is not immediately available or if heat exchanger 21 is not operational. Waste heat from the refrigerating liquefaction process is available, or can be dissipated in the sea.

When the LNG arrives on land it is stored at 41. When required for use it is vapourised in the heat exchanger of liquefaction plant 12 and then used as a source of supply 42.

The above-described arrangement has the advantage of providing economic handling and transport of large volumes of high energy gas. The volume reduction during liquefaction is approximately in the ratio 600:1 so that the transport of the ensuing high value cargo becomes viable. Although the injection of oil wells with nitrogen for the purpose of Enhanced Oil Recovery has not yet been shown to be economically viable in its own right, the calculations show a different result if nitrogen is readily available on site as a by-product of the liquefaction process.

Because the liquefaction plant at the well-head is basically a simple heat exchanger, the relatively high cost of providing a full-scale rcycling refrigerating liquefaction plant at the relatively inaccessible site is avoided. The wellhead liquefaction plant is mobile so that it can be moved from wellhead to wellhead as each is exhausted in turn. This further helps to keep costs down.

The LNG stored at 41 may be used for coping with excessive demand (i.e. peak-lopping) or emergency use. Since at present a proportion of natural gas needs to be specially liquefied for this purpose, this provides further savings. In addition the provision of the heat exchanger of liquefaction plant 12 reduces the external energy requirements of the plant, and economic exploitation of the oxygen and other products provided at 14 may further increase the savings made.

Various modifications may be made to the above-described arrangement. The wellhead recycling liquefaction plant 31 be omitted if desired. The invention is not restricted to a land site and an offshore site; it may be applied to any situation where there is a first site where liquefaction of a gas such as nitrogen can be relatively easily effected and a second site where conditions make it impracticable to provide a full-scale liquefaction plant of the recycling type, and where an EOR process can usefully be employed.

The heat exchanger of the land-based liquefaction plant 21 may be omitted so that the plant operates completely independently of the incoming LNG. In this case plant 12 is a conventional refrigerating plant employing solely recirculation of a refrigerant.

CLAIMS

1. A method of handling natural gas and oil from a relatively inaccessible site comprising liquefying a cooling medium at a relatively accessible site, transporting the liquefied cooling medium to the relatively inaccessible site, and passing it through a first branch of a heat exchanger and simultaneously passing natural gas through the second branch of the heat exchanger, thus liquefying the natural gas, the cooling medium then being employed in an enhanced oil recovery process at the relatively inaccessible site.

2. A method according to Claim 1, wherein the cooling medium is nitrogen.

3. A method according to Claim 1 or 2, wherein the cooling medium is passed through a compressor and/or a heater before being employed in the enhanced oil recovery process.

4. A method according to any preceding Claim, wherein the relatively inaccessible site is an off-shore platform upon which the heat exchanger is mounted, and after liquefaction of the natural gas it is transported away from the platform.

5. A method according to any of Claims 1 to 3, wherein the relatively inaccessible site is an offshore wellhead, the heat exchanger being located in a sea-going vessel arranged to be stationed near the wellhead, and after liquefaction of the natural gas it is transported away from the wellhead, said transportation steps of the liquefied cooling medium and the liquefied natural gas being by means of further sea-going vessels.

6. A natural gas liquefaction and enhanced oil recovery plant suitable for provision at a relatively inaccessible wellhead comprising a heat exchanger with a first branch arranged to receive liqued cooling medium and supply vapourised cooling medium and a second branch arranged to receive natural gas vapour and supply liquefied natural gas, the outlet of the first branch being connected to enhanced oil recovery apparatus.

7. A plant according to Claim 6, wherein the cooling medium is nitrogen.

8. A plant according to Claim 6 or 7, and additionally comprising a relatively small refrigerating liquefaction plant.

9. A plant according to any of claims 6 to 8, wherein a compressor and/or a heater is/are connected between the outlet of the first branch and the inlet of the enhanced oil recovery apparatus.

10. A plant according to Claim 9, wherein the compressor and/or the heater is/are supplied with

energy derived from fuel from the wellhead.

11. A method of handling natural gas and oil comprisng using a cooling medium to liquefy the natural gas and then using the cooling medium in an enhanced oil recovery process.

12. A method of handling natural gas and oil substantially as herein described with reference to the accompanying drawing.

13. A natural gas liquefaction and enhanced oil recovery plant substantially as herein described with reference to the accompanying drawing.

14. As an independent invention the additional feature of any of claims 2 to 5 or 7 to 10.

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